IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

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| In re Application of: | Shilin Chen |
| Serial No.: | To be Assigned |
| Filing Date: | January 26, 2004 |
| Group Art Unit: | To be Assigned |
| Examiner: | To be Assigned |
| Title: | **FORCE-BALANCED ROLLER-CONE BITS, SYSTEMS, DRILLING METHODS, AND DESIGN METHODS** |

Commissioner of Patents
P.O. Box 1450
Alexandria, VA 22313-1450

Dear Sir:

**REQUEST FOR INTERFERENCE WITH PATENT APPLICATION PURSUANT TO 37 C.F.R. 1.604**

The present Application includes Claims 1-5 copied from U.S. Patent Application No. 10/411,542 (the "'542 Application"), published on October 16, 2003 (Publication No. U.S. 2003/0195733 A1). Accordingly, Applicant respectfully requests that the Examiner declare an Interference between the present Application and the '542 Application in view of the following comments.

**CLAIMS**

For the convenience of the Examiner, all pending claims of the present Application are shown below in numerical order.

1. A method for optimizing a design of a roller cone drill bit, comprising:
simulating the bit drilling through a selected earth formation;
adjusting at least one design parameter of the bit;
repeating the simulating the bit drilling; and
repeating the adjusting and the simulating until a lateral force on the bit is optimized.

2. A method for balancing lateral forces on a plurality of roller cones on a roller cone drill bit during drilling, comprising:

(a) calculating, from a geometry of cutting elements on each of the roller cones and an earth formation to be drilled by the bit, a lateral force on each of the cutting elements;

(b) simulating incrementally rotating the bit and recalculating the lateral force on each of the cutting elements;

(c) repeating the simulating incrementally rotating and recalculating for a selected number of incremental rotations;

(d) combining the lateral force on the cutting elements on each one of the roller cones to determine the lateral force on each of the roller cones;

(e) adjusting at least one bit design parameter and repeating (a) through (d); and

(f) repeating (e) at least until a difference between the lateral force on each of the roller cones is less than the difference between the lateral force on each of the roller cones determined prior to the adjusting the at least one bit design parameter.

3. The method as defined in Claim 2 wherein the at, least one bit design parameter comprises a number of cutting elements on at least one of the cones.

4. The method as defined in Claim 2 wherein the at least one bit design parameter comprises a location of cutting elements on at least one of the cones.

5. The method as defined in Claim 2 wherein the at least one bit design parameter comprises an orientation of at least one of the cutting elements on at least one of the cones.

## REMARKS

Claims 1-5 are copied from the '542 Application and correspond to Claims 1-5, respectively, of the '542 Application.

Applicant's compliance with 37 C.F.R. §1.604 with respect to Applicant's request that the Examiner declare an Interference between the present Application and the '542 Application, is indicated below:

### I. 37 C.F.R. §1.604(a)(1)

Applicant proposes the following count:

A method for optimizing a design of a roller cone drill bit, comprising:

simulating the bit drilling through a selected earth formation;

adjusting at least one design parameter of the bit;

repeating the simulating the bit drilling; and

repeating the adjusting and the simulating until a lateral force on the bit is optimized.

Claim 1 of the present Application corresponds exactly to the count.

### II. 37 C.F.R. §1.604(a)(2)

Applicant respectfully requests that the Examiner declare an interference between the present Application and U.S. Patent Application No. 10/411,542. Claim 1 of the '542 Application corresponds exactly to the proposed count of Section I, above.

## III. 37 C.F.R. §1.604(a)(3)

The Interference should be declared because, as shown by the table below, the present Application and the '542 Application claim the same invention.

| The Present Application | The '542 Application |
|---|---|
| 1. A method for optimizing a design of a roller cone drill bit, comprising:<br>simulating the bit drilling through a selected earth formation;<br>adjusting at least one design parameter of the bit;<br>repeating the simulating the bit drilling; and<br>repeating the adjusting and the simulating until a lateral force on the bit is optimized. | 1. A method for optimizing a design of a roller cone drill bit, comprising:<br>simulating the bit drilling through a selected earth formation;<br>adjusting at least one design parameter of the bit;<br>repeating the simulating the bit drilling; and<br>repeating the adjusting and the simulating until a lateral force on the bit is optimized. |
| 2. A method for balancing lateral forces on a plurality of roller cones on a roller cone drill bit during drilling, comprising:<br>(a) calculating, from a geometry of cutting elements on each of the roller cones and an earth formation to be drilled by the bit, a lateral force on each of the cutting elements;<br>(b) simulating incrementally rotating the bit and recalculating the lateral force on each of the cutting elements;<br>(c) repeating the simulating incrementally rotating and recalculating for a selected number of incremental rotations;<br>(d) combining the lateral force on the cutting elements on each one of the roller cones to determine the lateral force on each of the roller cones;<br>(e) adjusting at least one bit design parameter and repeating (a) through (d); and | 2. A method for balancing lateral forces on a plurality of roller cones on a roller cone drill bit during drilling, comprising:<br>(a) calculating, from a geometry of cutting elements on each of the roller cones and an earth formation to be drilled by the bit, a lateral force on each of the cutting elements;<br>(b) simulating incrementally rotating the bit and recalculating the lateral force on each of the cutting elements;<br>(c) repeating the simulating incrementally rotating and recalculating for a selected number of incremental rotations;<br>(d) combining the lateral force on the cutting elements on each one of the roller cones to determine the lateral force on each of the roller cones;<br>(e) adjusting at least one bit design parameter and repeating (a) through (d); and |

| The Present Application | The '542 Application |
|---|---|
| (f) repeating (e) at least until a difference between the lateral force on each of the roller cones is less than the difference between the lateral force on each of the roller cones determined prior to the adjusting the at least one bit design parameter. | (f) repeating (e) at least until a difference between the lateral force on each of the roller cones is less than the difference between the lateral force on each of the roller cones determined prior to the adjusting the at least one bit design parameter. |
| 3. The method as defined in Claim 2 wherein the at, least one bit design parameter comprises a number of cutting elements on at least one of the cones. | 3. The method as defined in claim 2 wherein the at, least one bit design parameter comprises a number of cutting elements on at least one of the cones. |
| 4. The method as defined in Claim 2 wherein the at least one bit design parameter comprises a location of cutting elements on at least one of the cones. | 4. The method as defined in claim 2 wherein the at least one bit design parameter comprises a location of cutting elements on at least one of the cones. |
| 5. The method as defined in Claim 2 wherein the at least one bit design parameter comprises an orientation of at least one of the cutting elements on at least one of the cones. | 5. The method as defined in claim 2 wherein the at least one bit design parameter comprises an orientation of at least one of the cutting elements on at least one of the cones. |

There are no differences between Claims 1-5 of the present Application and Claims 1-5 of the '542 Application listed side-by-side above. Thus, it is clear that the parties are claiming the same patentable invention.

## IV. 37 C.F.R. §1.604(a)(5) SUPPORT FOR COPIED CLAIMS

Applicant respectfully contends that Claims 1-5 of the present Application are fully supported by the specification of the present Application, as originally filed. Applicant provides below, examples of specific portions of the specification that support specific claim limitations of Claims 1-5. Applicant does not intend this list to be exhaustive of all support for Claims 1-5 that is present in the specification of the present Application.

For the convenience of the Examiner, Applicant has reproduced specific portions of the specification of the present Application, in the attached Exhibit A. Such portions were reproduced from the cited "Support in the Specification", below, and are applied to their respective claim limitations in Exhibit A.

| **Claims** | **Support in the Specification** |
|---|---|
| 1. A method for optimizing a design of a roller cone drill bit, comprising: | Page 9, lines 11-12. |
| simulating the bit drilling through a selected earth formation; | Page 12, lines 18-19.<br>Page 14, lines 25-27. |
| adjusting at least one design parameter of the bit; | Page 17, lines 21-23. |
| repeating the simulating the bit drilling; and | Page 12, lines 18-19.<br>Page 17, lines 23-24. |
| repeating the adjusting and the simulating until a lateral force on the bit is optimized. | Page 12, line 17 - Page 13, line 11. |
| 2. A method for balancing lateral forces on a plurality of roller cones on a roller cone drill bit during drilling, comprising: | Page 11, lines 12-19.<br>Page 12, line 27 - Page 13, line 13.<br>Page 15, line 27 - Page 16, line 4.<br>Page 16, lines 17-18. |

| Claims | Support in the Specification |
|---|---|
| (a) calculating, from a geometry of cutting elements on each of the roller cones and an earth formation to be drilled by the bit, a lateral force on each of the cutting elements; | Page 11, lines 6-29. |
| (b) simulating incrementally rotating the bit and recalculating the lateral force on each of the cutting elements; | Page 12, lines 3-21. |
| (c) repeating the simulating incrementally rotating and recalculating for a selected number of incremental rotations; | Page 12, lines 18-19. |
| (d) combining the lateral force on the cutting elements on each one of the roller cones to determine the lateral force on each of the roller cones; | Page 12, lines 15-17. |
| (e) adjusting at least one bit design parameter and repeating (a) through (d); and | Page 15, line 27 - Page 16, line 4. |
| (f) repeating (e) at least until a difference between the lateral force on each of the roller cones is less than the difference between the lateral force on each of the roller cones determined prior to the adjusting the at least one bit design parameter. | Page 15, line 27 - Page 16, line 4. |
| 3. The method as defined in Claim 2 wherein the at, least one bit design parameter comprises a number of cutting elements on at least one of the cones. | Page 13, lines 22-23. |
| 4. The method as defined in Claim 2 wherein the at least one bit design parameter comprises a location of cutting elements on at least one of the cones. | Page 13, lines 22-23. |
| 5. The method as defined in Claim 2 wherein the at least one bit design parameter comprises an orientation of at least one of the cutting elements on at least one of the cones. | Page 13, line 22 - Page 14, line 2. |

## V. REQUEST FOR THE BENEFIT OF THE FILING DATES OF APPLICANT'S PRIORITY APPLICATIONS

Applicant claims priority under 35 U.S.C. 120 based upon U.S. Patent Application Serial No. 10/383,805 (the "'805 Application"), filed March 8, 2003, which is a continuation from U.S. Patent Application Serial No. 09/833,016 (the "'016 Application"), filed April 10, 2001, which is a continuation of U.S. Patent Application Serial No. 09/387,737 (the "'737 Application"), filed August 31, 1999, now U.S. Patent No. 6,213,225. The present Application is a continuation of the '805 Application, which is a continuation of the '016 Application which is a continuation of the '737 Application. Therefore, the application of the terms of Claims 1-5 to the specification of the present Application in Section IV above applies to the '805, '016 and '737 Applications as well.

The August 31, 1999 filing date of the '737 Application precedes the June 8, 2000 filing date of the U.S. Patent Application No. 09/590,577, now U.S. Patent No, 6,612,384, of which the '542 Application is a continuation. Therefore, Chen should be the senior party in the interference.

Applicant further claims priority under 35 U.S.C. 119(e) based on provisional application No. 60/098,466 filed August 31, 1998. Applicant is entitled to the benefit of the filing dates of his earlier filed applications for interference purposes if the count reads on at least one adequately disclosed embodiment in the earlier application.[1]

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[1] *See Weil v. Fritz*, 572 F.2d 856, 865-66 n.16, 196 USPQ 600, 608 n.16 (CCPA 1978).

**CONCLUSION**

Applicant has made an earnest attempt to place this case in condition for allowance. For the foregoing reasons, and for other reasons clearly apparent, Applicant respectfully requests full allowance of all pending claims. Furthermore, Applicant respectfully requests that the Examiner declare an Interference between the present Application and the '542 Application. If the Examiner feels that a telephone conference or an interview would advance prosecution of the present Application in any manner, the undersigned attorney for Applicant stands ready to conduct such a conference at the convenience of the Examiner.

If the Examiner determines that at least one of the claims copied from the '542 Application is allowable, Applicant respectfully requests that the Examiner declare an interference, in accordance with MPEP 2303, which states that "[i]f the applications each contain one claim drawn to the same patentable invention (37 CFR 1.601(n)), the examiner proceeds to propose the interference . . . ." *See MPEP 2303.*

The Commissioner is hereby authorized to charge any fees or credit any overpayments to Deposit Account No. **50-2148** of Baker Botts L.L.P.

Respectfully submitted,

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**EXHIBIT A**
**Support for Claims 1-5**

Reproduced below, are portions of the specification of the present Application that are examples of support in the present Application for each limitation of Claims 1-5 delineated below. This list is not intended to be exhaustive.

## I. Support for Claim 1

### A. *A method for optimizing a design of a roller cone drill bit, comprising:*

1. Designer can optimize the design of roller cone drill bits within designer-chosen constraints. *See Present Application, Page 9, lines 11-12.*

### B. *simulating the bit drilling through a selected earth formation;*

1. (5) After the bit is fully drilled into the rock, these forces are recorded at each time step. A period time usually at least 10 seconds is simulated. *See Present Application, Page 12, lines 18-19.*

2. $V_{3d0}$ is obtained from the rock bit computer program by simulate the bit drilling procedure at least 10 seconds. *See Present Application, Page 14, lines 25-27.*

### C. *adjusting at least one design parameter of the bit;*

1. (d) adjusting at least one geometric parameter on the design of at least one cutting structure. *See Present Application, Page 17, lines 21-23.*

### D. *repeating the simulating the bit drilling;*

1. (5) After the bit is fully drilled into the rock, these forces are recorded at each time step. A period time usually at least 10 seconds is simulated. *See Present Application, Page 12, lines 18-19.*

2. (e) repeating steps (a) through (d) until substantially the same volume of formation is cut by each of said cutting structures of said bit. *See Present Application, Page 17, lines 23-24.*

### E. *repeating the adjusting and the simulating until a lateral force on the bit is optimized.*

1. With reference to **Figure 2**, the balance condition of a roller cone bit may be evaluated using the following criteria:

$$\mathrm{Max}\,(\omega 1, \omega 2, \omega 3) - \mathrm{Min}\,(\omega 1, \omega 2, \omega 3) <= \omega 0 \qquad (4)$$

$$\mathrm{Max}\,(\eta 1, \eta 2, \eta 3) - \mathrm{Min}\,(\eta 1, \eta 2, \eta 3) <= \eta 0 \qquad (5)$$

$$\text{Max}(\lambda1, \lambda2, \lambda3) - \text{Max}(\lambda1, \lambda2, \lambda3) <= \lambda0 \quad (6)$$

$$\xi = F_r \ / \ WOB * 100\ \% <= \xi0 \quad (7)$$

where ωi (i = 1, 2, 3) is defined by ωi = WOBi / WOB * 100 %, WOBi is the weight on bit taken by cone i. ηi is defined by ηi = Fzi / ΣFzi * 100 % with Fzi being the i-th cone axial force. And λi is defined by λi = Mzi / ΣMzi * 100 % with Mzi being the i-th cone moment in the direction perpendicular to i-th cone axis. Finally ξ is the bit imbalance force ratio with $F_r$ being the bit imbalance force. A bit is perfectly balanced if:

$$\omega1 = \omega2 = \omega3 = 33.333\ \% \text{ or } \omega0 = 0.0\ \%$$

$$\eta1 = \eta2 = \eta3 = 33.333\ \% \text{ or } \eta0 = 0.0\ \%$$

$$\lambda1 = \lambda2 = \lambda3 = 33.333\ \% \text{ or } \lambda0 = 0.0\ \%$$

$$\xi = 0.0\ \%.$$

In most cases if ω0, η0, λ0, ξ0 are controlled with some limitations, the bit is balanced. *See Present Application, Page 12, line 27 through Page 13, line 13.*

## II. Support for Claim 2

**A.** ***A method for balancing lateral forces on a plurality of roller cones on a roller cone drill bit during drilling, comprising:***

1. The force-cutting relationship for this single element may be described by:

$$F_{ze} = k_e * \sigma * S_e \quad (1)$$

$$F_{xe} = \mu_x * F_{ze} \quad (2)$$

$$F_{ye} = \mu_y * F_{ze} \quad (3)$$

where $F_{ze}$ is the normal force and $F_{xe}$, $F_{ye}$ are side forces, respectively, σ is the compressive strength, $S_e$ the cutting depth and $k_e$, $\mu_x$ and $\mu_y$ are coefficient associated with formation properties. These coefficients may be determined by lab test. *See Present Application, Page 11, lines 12-19.*

2. With reference to **Figure 2**, the balance condition of a roller cone bit may be evaluated using the following criteria:

$$\text{Max}(\omega1, \omega2, \omega3) - \text{Min}(\omega1, \omega2, \omega3) <= \omega0 \quad (4)$$

$$\text{Max}(\eta1, \eta2, \eta3) - \text{Min}(\eta1, \eta2, \eta3) <= \eta0 \quad (5)$$

$$\text{Max}(\lambda1, \lambda2, \lambda3) - \text{Max}(\lambda1, \lambda2, \lambda3) <= \lambda0 \quad (6)$$

$$\xi = F_r \ / \ WOB * 100\ \% <= \xi0 \quad (7)$$

where ωi (i = 1, 2, 3) is defined by ωi = WOBi / WOB * 100 %, WOBi is the weight on bit taken by cone i. ηi is defined by ηi = Fzi / ΣFzi * 100 % with Fzi being the i-th

cone axial force. And $\lambda i$ is defined by $\lambda i = Mzi / \Sigma Mzi * 100\ \%$ with Mzi being the i-th cone moment in the direction perpendicular to i-th cone axis. Finally $\xi$ is the bit imbalance force ratio with $F_r$ being the bit imbalance force. A bit is perfectly balanced if:

$$\omega 1 = \omega 2 = \omega 3 = 33.333\ \% \text{ or } \omega 0 = 0.0\ \%$$

$$\eta 1 = \eta 2 = \eta 3 = 33.333\ \% \text{ or } \eta 0 = 0.0\ \%$$

$$\lambda 1 = \lambda 2 = \lambda 3 = 33.333\ \% \text{ or } \lambda 0 = 0.0\ \%$$

$$\xi = 0.0\ \%.$$

In most cases if $\omega 0$, $\eta 0$, $\lambda 0$, $\xi 0$ are controlled with some limitations, the bit is balanced. *See Present Application, Page 12, line 27 through Page 13, line 13.*

3. The procedure begins by reading the bit geometry and other operational parameters. The forces on the teeth, cones, bearings, and bit are then calculated. Once the forces are known, they are compared, and if they are balanced, then the design is optimized. If the forces are not balanced, then the optimization must occur. Objectives, constraints, design variables and their bounds (maximum and minimum allowed values) are defined, and the variables are altered to conform to the new objectives. Once the new objectives are met, the new geometric parameters are used to re-design the bit, and the forces are again calculated and checked for balance. This process is repeated until the desired force balance is achieved. *See Present Application, Page 15, line 27 through Page 16, line 4.*

4. By balancing the volume of formation removed by all cutting structures, force balancing is also achieved. *See Present Application, Page 16, lines 17-18.*

**B.** ***(a) calculating, from a geometry of cutting elements on each of the roller cones and an earth formation to be drilled by the bit, a lateral force on each of the cutting elements;***

1. <u>Rock Bit Computer Model</u>

The present invention uses a single element force-cutting relationship in order to develop the total force-cutting relationship of a cone and of an entire roller cone bit. Looking at Figure 1, each tooth, shown on the right side, can be thought of as composed of a collection of elements, such as are shown on the left side. Each element used in the present invention has a square cross section with area $S_e$ (its cross-section on the x-y plane) and length $L_e$ (along the z axis). The force-cutting relationship for this single element may be described by:

$$F_{ze} = k_e * \sigma * S_e \quad (1)$$

$$F_{xe} = \mu_x * F_{ze} \quad (2)$$

$$F_{ye} = \mu_y * F_{ze} \quad (3)$$

where $F_{ze}$ is the normal force and $F_{xe}$, $F_{ye}$ are side forces, respectively, $\sigma$ is the compressive strength, $S_e$ the cutting depth and $k_e$, $\mu_x$ and $\mu_y$ are coefficient associated with formation properties. These coefficients may be determined by lab test. A tooth or an insert can always be divided into several elements. Therefore, the total force on a tooth can be obtained by integrating equation (1) to (3). The single element force model used in the invention has significant advantage over the single tooth or single insert model used in most of the publications. The only way to obtain a force model is by lab test. There are many types of inserts used today for roller cone bit depending on the rock type drilled. If the single insert force model is used, a lot of tests have to be done and this is very difficult if not impossible. By using the element force model, only a few tests may be enough because any kind of insert or tooth can be always divided into elements. In other words, one element model may be applied to all kinds of inserts or teeth. *See Present Application, Page 11, lines 6-29.*

**C.** ***(b) simulating incrementally rotating the bit and recalculating the lateral force on each of the cutting elements;***

1. (1) The bit kinematics is described by bit rotation speed, $\Omega$=RPM (revolutions per minute), and the rate of penetration, ROP. Both RPM and ROP may be considered as constant or as function with time.

(2) The cone kinematics is described by cone rotational speed. Each cone may have its own speed. The initial value is calculated from the bit geometric parameters or just estimated from experiment. In the calculation the cone speed may be changed based on the torque acting on the cone.

(3) At the initial time, t0, the hole bottom is considered as a plane and is meshed into small grids. The tooth is also meshed into grids (single elements). At any time t, the position of a tooth in space is fully determined. If the tooth is in interaction with the hole bottom, the hole bottom is updated and the cutting depth for each cutting element is calculated and the forces acting on the elements are obtained.

(4) The element forces are integrated into tooth forces, the tooth forces are integrated into cone forces, the cone forces are transferred into bearing forces and the bearing forces are integrated into bit forces.

(5) After the bit is fully drilled into the rock, these forces are recorded at each time step. A period time usually at least 10 seconds is simulated. The average forces may be considered as static forces and are used for evaluation of the balance condition of the cutting structure. *See Present Application, Page 12, lines 3-21.*

**D.** ***(c) repeating the simulating incrementally rotating and recalculating for a selected number of incremental rotations;***

1. (5) After the bit is fully drilled into the rock, these forces are recorded at each time step. A period time usually at least 10 seconds is simulated. *See Present Application, Page 12, lines 18-19.*

**E.** ***(d) combining the lateral force on the cutting elements on each one of the roller cones to determine the lateral force on each of the roller cones;***

1. (4) The element forces are integrated into tooth forces, the tooth forces are integrated into cone forces, the cone forces are transferred into bearing forces and the bearing forces are integrated into bit forces. *See Present Application, Page 12, lines 15-17.*

**F.** ***(e) adjusting at least one bit design parameter and repeating (a) through (d); and***

1. See Paragraph II(A)(3). *See Present Application, Page 15, line 31 through Page 16, line 4.*

**G.** ***(f) repeating (e) at least until a difference between the lateral force on each of the roller cones is less than the difference between the lateral force on each of the roller cones determined prior to the adjusting the at least one bit design parameter.***

1. See Paragraph II(A)(3). *See Present Application, Page 15, line 27 through Page 16, line 4.*

**III. Support for Claim 3**

**A.** ***The method as defined in Claim 2 wherein the at, least one bit design parameter comprises a number of cutting elements on at least one of the cones.***

1. Among these parameters, the teeth crest length, their positions on cones (row distribution on cone) and the number of teeth play a significant role. *See Present Application, Page 13, lines 22-23.*

**IV. Support for Claim 4**

**A.** ***The method as defined in Claim 2 wherein the at least one bit design parameter comprises a location of cutting elements on at least one of the cones.***

1. See Paragraph III(A)(1). *See Present Application, Page 13, lines 22-23.*

**V. Support for Claim 5**

**A.** ***The method as defined in Claim 2 wherein the at least one bit design parameter comprises an orientation of at least one of the cutting elements on at least one of the cones***

1. Among these parameters, the teeth crest length, their positions on cones (row distribution on cone) and the number of teeth play a significant role. An increase in the size of any one parameter must of necessity result in the decrease or increase of one or more of the others. And in some cases design rules may be violated. Obviously the development of optimization procedure is absolutely necessary. The first step in the optimization procedure is to choose the design

variables. Consider a cone of a steel tooth bit as shown in Figure 3. The cone has three rows. For the sake of simplicity, the journal angle, the offset and the cone profile will be fixed and will not be as design variables. Therefore the only design variables for a row are the crest length, Lc, the radial position of the center of the crest length, Rc, and the tooth angles, $\alpha$ and $\beta$. Therefore, the number of design variables is 4 times of the total number of rows on a bit. *See Present Application, Page 13, line 22 through Page 14, line 2.*